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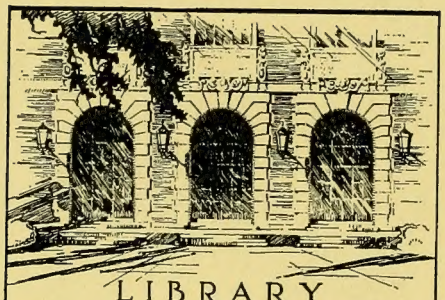

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An Inventory of THE FISHES OF JORDAN CREEK, Vermilion County, Illinois

R. Weldon Larimore
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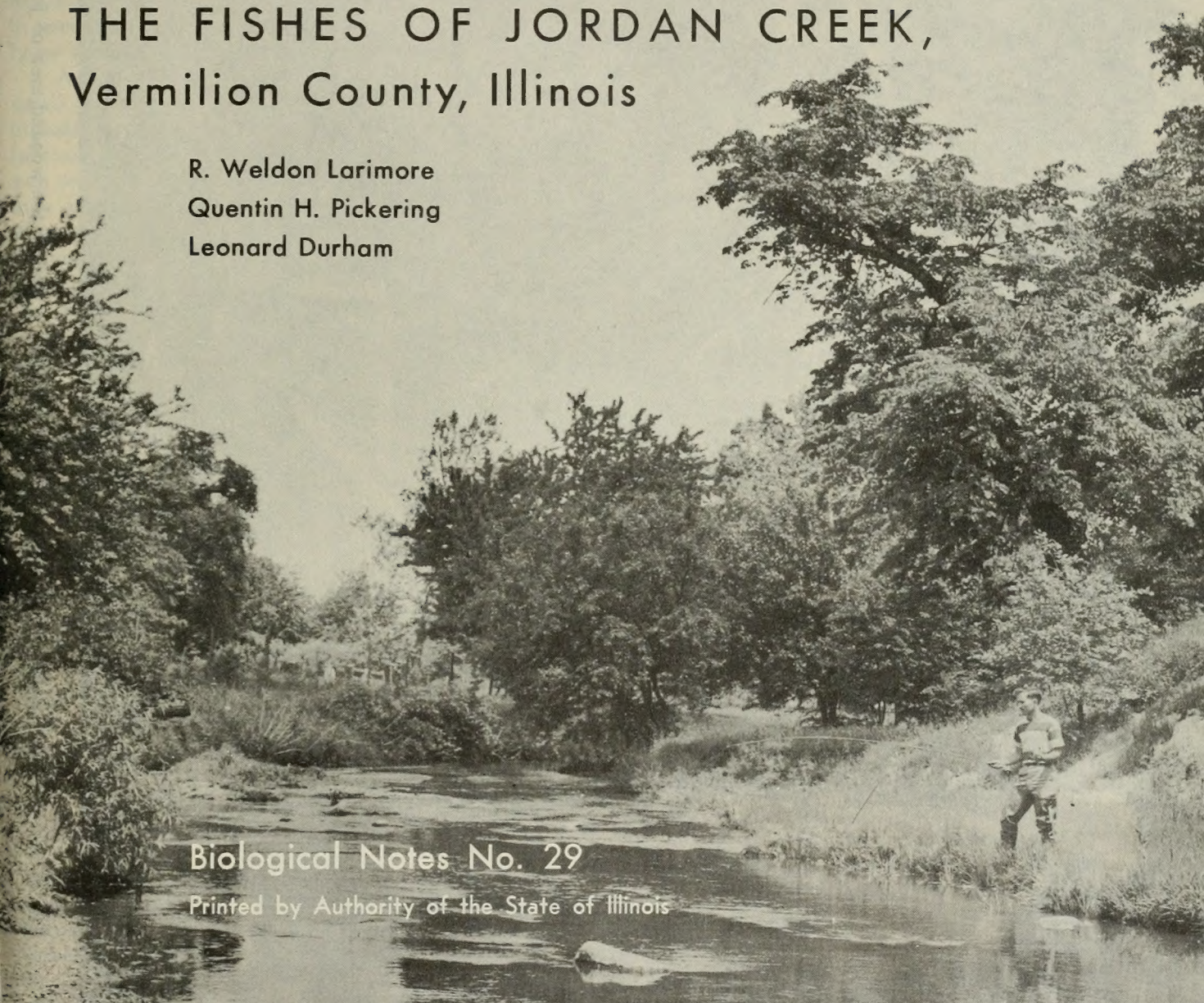

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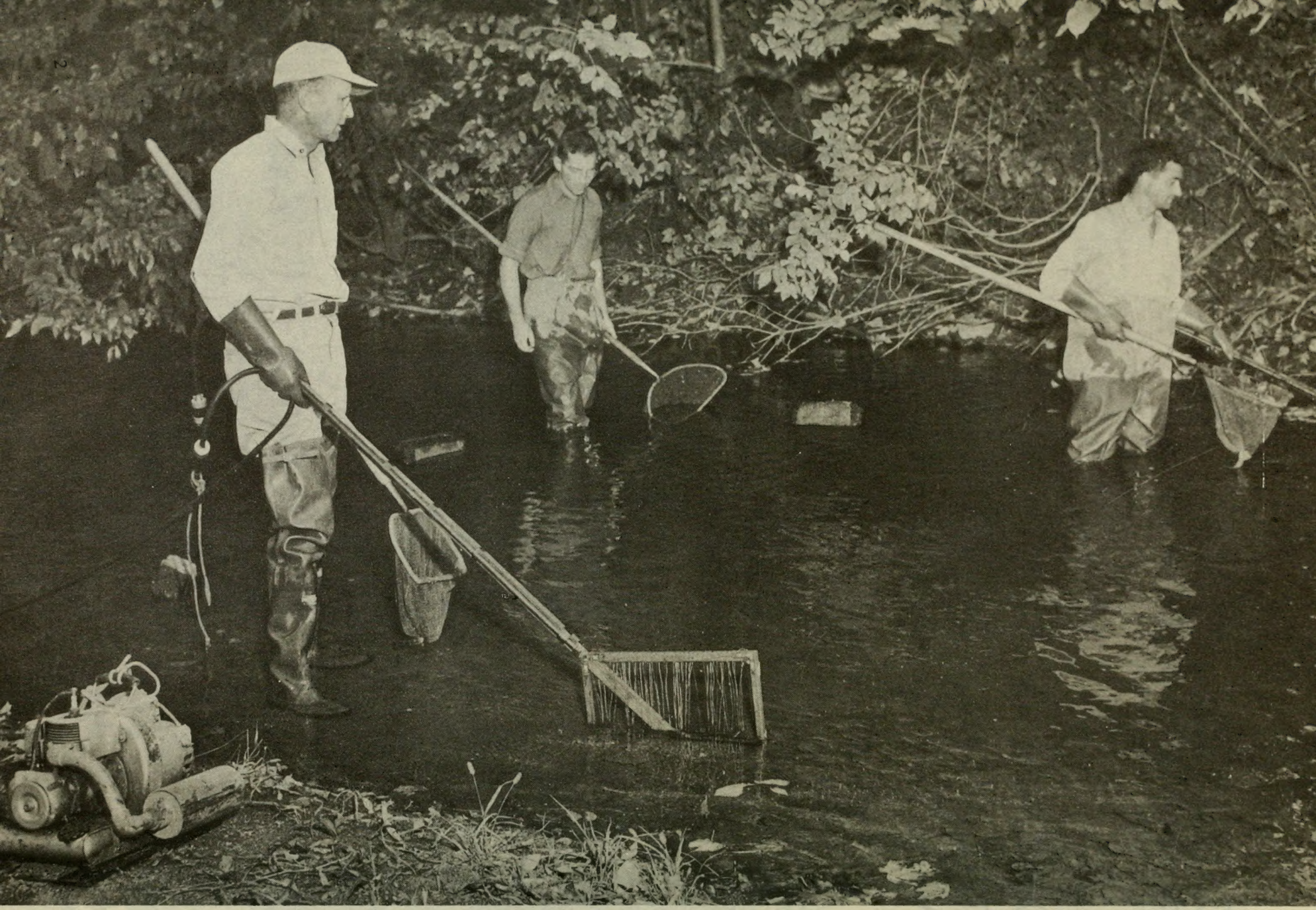

Fig. 1. -- An electric seine being used to collect fish from a pool in the wooded area of Jordan Creek.

An Inventory of THE FISHES OF JORDAN CREEK, Vermilion County, Illinois

R. Weldon Larimore, Quentin H. Pickering, and Leonard Durham*

Many streams and small rivers transect the upland prairies of Illinois. Most of them drain rich agricultural lands and are strongly influenced by the farming practices of surrounding areas. Some have been dredged. Probably all of them receive large amounts of surface water during periods of heavy rainfall. Usually the runoff water carries a heavy silt load, which causes the streams and rivers to become very turbid for a period of days or weeks. In some parts of Illinois, the streams are fed mainly by springs, in others mainly by drainage tiles.

A considerable number of these streams and small rivers support large populations of fishes, including several species of importance to anglers. In some parts of Illinois, stream fishing is a common practice, but in most of the state it is confined to a comparatively few individuals who are somewhat secretive about the sources of their catches. Consequently, the average Illinois angler thinks of fishing in terms of lakes.

Most of the fishery investigations on the smaller streams of Illinois have considered principally the distribution of species as related to the stream habitat (Forbes & Richardson 1920; Thompson & Hunt 1930). The concept of managing the stream habitat and the fishes of a stream for the improvement of angling has received little consideration.

As a preliminary to the development of fish management techniques for small streams, an intensive study of the fishes of Jordan Creek, a tributary of the Salt Fork of the Vermilion River in Vermilion County, east central Illinois, was begun in July, 1950. This study has been almost continuous since that time. The material included in this report is largely an analysis of an intensive inventory of the fish population made between July 25 and September 5, 1950.

Acknowledgments

The investigation reported here is part of the fisheries program of the Illinois Natural History Survey and has been jointly supported by the Survey and the Illinois Department of Conservation. Dr. George W. Bennett supervised the organization of the project and offered valuable suggestions for this report. Mr. Sam A. Parr, Superintendent of Fisheries, Department of Conservation, co-operated in this program by arranging for funds to aid the investigation.

Methods and Procedure

Field operations on Jordan Creek were begun by a crew of two or three men during the last week in July, 1950. Beginning at the mouth of the creek, the crew worked each pool and riffle with an electric apparatus that stunned but did not kill the fish. As the crew moved upstream, the pools were numbered and described. Continuous sampling was stopped at a distance of 4.02 miles above the stream mouth because sample collections indicated that few if any game fish were present above this point.

The electric apparatus for stunning the fish was operated from a portable 115-volt alternating current generator. At the beginning of the operation, two hand-carried electrodes were used in a manner described by Shetter (1947). Later an electric seine, a modification of that described by Funk (1949), was used in all collecting. This electric seine, 21 feet in length, allowed a complete sweep of the stream, fig. 1, except in a few especially wide pools. The difference in efficiency of these two fish shockers was not determined. The electric seine, however, was faster to use because it was effective over a greater area at one time. Stunned fish were picked up in dip nets. The quarter-inch mesh of the nets largely determined the minimum size of fish collected.

Game and pan fishes that were stunned by the electrical current and collected were kept alive in tubs and later released at the points of capture. Prior to release, the total length of each of these fish was recorded, scale samples were taken, and one or more fins were clipped for later recognition of the fish. Fin marks were changed at intervals of about a quarter mile of stream distance. Weights were taken of enough specimens to determine the length-weight relationship for each species and to allow an estimate of the weight of the fish that were only measured for lengths. Fish other than those considered as game and pan species were

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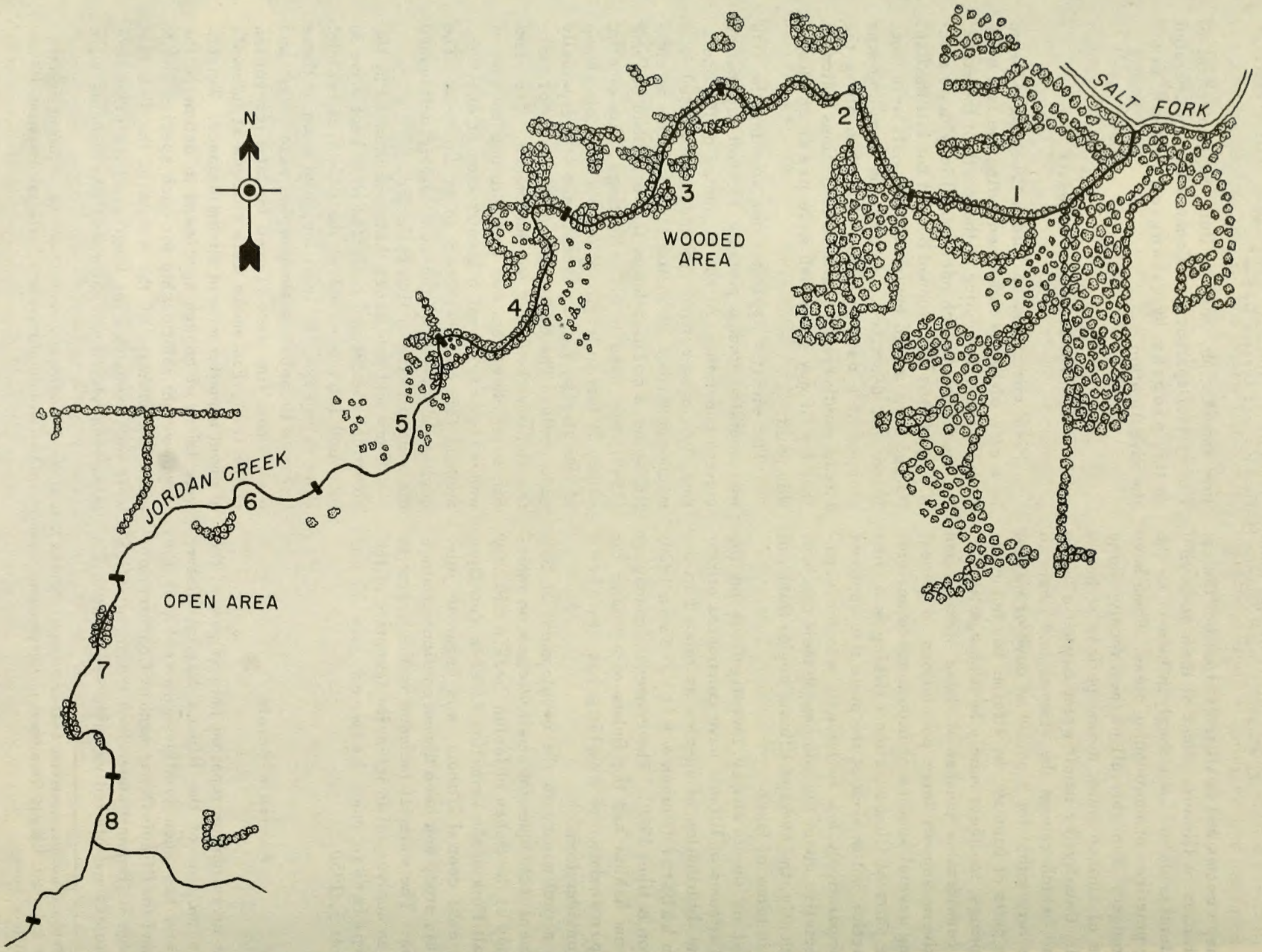


Fig. 2. -- Map of the Jordan Creek study section, indicating the limits of the eight divisions and the open and wooded areas, 1950.

removed from the stream, placed immediately in chipped ice, and brought to the laboratory for identifying, counting, and weighing. Fifty-two separate collections were made in this initial inventory.

After the initial inventory had been completed on September 5, 1950, the 4-mile length of stream under intensive study was marked off into eight divisions for further investigation of the stream itself and of the fish found in each division. As the divisions were set up, no pool was split; each pool was entirely within a single division. Fortunately, the lower seven divisions could be made equal in length (0.53 mile each), as determined from topographic maps and aerial photographs. Since these lower seven divisions were each slightly over one-half mile in extent, the eighth division of the 4-mile length was shorter than the others, only 0.31 mile in length. Deeper water and shade under a concrete road bridge that marked the upper limit of this last division attracted a concentration of fishes at that point. The fish populations censused in this division, even though modified by the shorter length of the stream and by the bridge, were compared with the populations in the other divisions.

During the months of September, October, and November, 1950, many pools were reworked once to several times. The same procedures were followed as were used during the initial census, except that the fishes returned to the stream were marked with numbered opercular tags. By repeated censuses of certain pools, much information was gathered concerning fish movements and the effects of removing a large percentage of the forage fish population. The fish taken in these repeat censuses are not included in the original tabulations, tables 2-9. However, several additional species collected during the fall months are included in the species list, table 1, and in the discussion of species.

Description of Drainage Basin

Jordan Creek, a warm-water stream 11 miles long, drains a glaciated area of 10.6 square miles in the southern part of Vermilion County. During the Glacial Epoch, at least two ice sheets, the Illinoian and the Wisconsin, covered this region. The more recent Wisconsin glacier largely determined the topography and soils. The source of Jordan Creek is in a part of Vermilion County that was left as a flat, marshy area by the last glaciation. The soils of this flat area are primarily of two types: Drummer clay loam and Brenton silt loam (Wascher, Smith, & Smith 1938). These soils were formed under slough-grass and prairie-grass vegetation. Because of the poor natural drainage of this flat land, the upper half of Jordan Creek was dredged to improve the drainage and make these soils suitable for farming.

The stream flows northward out of this flat land into an area of rolling to rough topography. Here the stream has not been dredged. In this lower part of Jordan Creek is the 4-mile study section, which is divided naturally into two contrasting habitats of about equal lengths: a lower, wooded area and an upper, open area.

Lower, Wooded Area.--This area, which includes the first 2 miles above the mouth of Jordan Creek, covers the lower four divisions of the study section, fig. 2. Here the rough, rolling land through which the stream flows has scattered ridges of glacial materials and frequent outcroppings of bedrock.

In this area Jordan Creek falls an average of 24 feet per mile. Flowing rapidly across the exposed edges of underlying rock strata as it nears the Vermilion River, the stream forms more frequent pools and steeper riffles than in the upper area. Besides the siltstone, sandstone, and shale that comprise the bedrock, gravel is a predominant bottom material. Sand and silt bottoms are not common. Midway in this lower, wooded area, the volume of stream flow is approximately 18.6 cubic feet per second at average water levels.

Heavy vegetation covers most of the stream banks in the lower area, fig. 3. American elms, sugar maples, silver maples, cottonwoods, sycamores, and many other large trees shade the water. Even away from the wooded creek margins there are extensive stands of hardwood timber. Farming is limited primarily to stock raising on permanent pastures. Vance silt loam is the common soil type in the lower half of the study section (Wascher, Smith, & Smith 1938). This soil erodes easily, so that plowing is limited to a few flat areas and small garden plots.

Upper, Open Area.--The upper half of the study section, which is in open farm and pasture land, includes the 2 miles of stream in the upper four divisions, fig. 2. The topography of this area is flat to rolling. Generally only 10 to 15 feet of soil covers the bedrock, but there are no outcroppings except in the bed of Jordan Creek. The stream has cut through the overlying soil, so that its gradient and bottom materials are determined largely by the bedrock.

In this area, in contrast to the wooded area, the stream flows over the flat surfaces of rock strata and only occasionally cuts entirely through

Fig. 3. -- A part of the lower, wooded area of Jordan Creek, showing steep riffles, short, rocky pools, and dense, shading vegetation.

Fig. 4. -- A long pool in the upper, open area of Jordan Creek.

a layer. The open area has fewer steep riffles than the wooded area. The pools are long and quiet, fig. 4. The stream gradient averages 9.7 feet per mile and there is a flow of about 12.9 cubic feet per second at average water levels. Even though bedrock and coarse gravel comprise the dominant bottom materials, there are extensive accumulations of sand and silt in the long pools.

Catlin silt loam is the predominant soil type (Wascher, Smith, & Smith 1938) in the upper half of the study section. This soil does not erode easily and it is suitable for alfalfa, clover, corn, and soybeans. The land is farmed rather intensively and, even though about one-third of it is in permanent pasture, there are few trees. Most of the stream in this half of the study section is exposed to direct sunlight, fig. 4, being shaded in only a few places by groups of cottonwoods and American elms or low, overhanging shrubs.

The sharp contrast between these two habitats, figs. 3 and 4, affords an opportunity to evaluate the influence of various environmental conditions on the stream fauna. The situation produced by these very different habitats is unusual in that features ordinarily associated with lower parts of streams--low gradient, long pools, and slow current--are characteristic of the upper, open area, whereas the more typical upstream features are found in the lower, wooded area.

Composition of the Fish Population

Quantitative data on the fish population of Jordan Creek, as given below and in tables 2-9, include only those fish actually collected during the initial census (July 25 through September 5, 1950); no estimates are given of the numbers missed in collecting, and no attempt is made to evaluate the population during other times of the year.

After a period of high water in the fall of 1950, several species were taken that were not represented in the first inventory. These species are included in the list of 40 species, table 1, and mentioned in the discussion of families. The common names of fishes are used throughout the discussions. These names, as well as the scientific names in table 1, are those suggested by the American Fisheries Society (1948), except as indicated otherwise.

Tables 2-7 are set up to show the distribution of most species in the study section. The species in each table are arranged in descending order of weight represented in the take; those represented by only a few specimens are not included. Since attempts have been made to classify streams on the basis of the fish family that dominates them--as bass streams, sucker streams, or minnow streams--the distribution patterns of families are also considered and then a summary is given, tables 8 and 9, for the five most abundant families.

In the brief discussions of species that follow in systematic order, the distribution of fishes in the study section is considered in relation to four primary ecological factors--stream gradient, amount of water shaded, dominant bottom material, and use of the surrounding land. Table 10 is a summary of this relationship.

Sucker Family

The suckers varied more in abundance in the several divisions of the stream than either the minnows or sunfishes, table 8. The actual number of suckers collected in each division of the stream was approximately inversely proportional to the stream gradient, whereas the actual weight seemed to be related to the number of larger pools in each division. In relation to the other families of fishes, the suckers increased in abundance from the mouth of the stream up through Division 4 but decreased progressively farther upstream, table 9. The distribution of each sucker species is discussed in the following paragraphs and summarized in table 2.

Quillback.--Fish of this species showed a preference for the soft mud bottoms and slow currents of the upper, open part of the stream. Of 167 specimens taken in seven collections, all but 1 were from the open area and 104 of these were from Division 8. The single specimen from the lower half of the study section was exceptional also in being the only specimen over 1 year of age.

White Sucker.--The larger individuals of this species were taken in relatively deep pools, particularly associated with rock ledges and moderate current. They usually attempted to avoid the electrical shock by swimming ahead but seemed especially sensitive to the electric current when forced to turn into the effective field. The fishermen around Jordan Creek catch this sucker during the spring months and value it highly as a food fish.

Hog Sucker.--By weight, the hog sucker was the most abundant fish in Jordan Creek. The young fish of this species were found in shallow riffles, whereas the adults usually were taken just below riffles in gravel-bottomed pools of moderate depth. The hog sucker and the white sucker frequently occurred together in collections but usually were

Table 1.--Common and scientific names of the fishes collected in Jordan Creek, 1950. Most names used are those given in Special Publication No. 1 of the American Fisheries Society (1948).

Common Name	Scientific Name
SUCKER FAMILY	**CATOSTOMIDAE**
Quillback	Carpiodes cyprinus (Le Sueur)
White sucker	Catostomus commersonnii (Lacépède)
Hog sucker	Hypentelium nigricans (Le Sueur)
Creek chubsucker	Erimyzon oblongus (Mitchill)
Spotted sucker	Minytrema melanops (Rafinesque)
Golden redhorse	Moxostoma erythrurum (Rafinesque)
MINNOW FAMILY	**CYPRINIDAE**
Carp	Cyprinus carpio Linnaeus
Creek chub	Semotilus atromaculatus (Mitchill)
Hornyhead chub	Nocomis biguttatus (Kirtland)
Rosyface shiner*	Notropis rubellus (Agassiz)
Redfin shiner	Notropis umbratilis (Girard)
Common shiner	Notropis cornutus (Mitchill)
Spotfin shiner*	Notropis spilopterus (Cope)
Sand shiner	Notropis deliciosus (Girard)
Suckermouth minnow*	Phenacobius mirabilis (Girard)
Silverjaw minnow*	Ericymba buccata Cope
Fathead minnow	Pimephales promelas Rafinesque
Bluntnose minnow	Hyborhynchus notatus (Rafinesque)
Stoneroller	Campostoma anomalum (Rafinesque)
CATFISH FAMILY	**AMEIURIDAE**
Black bullhead	Ameiurus melas (Rafinesque)
Yellow bullhead	Ameiurus natalis (Le Sueur)
Stonecat	Noturus flavus Rafinesque
Brindled madtom*	Schilbeodes miurus (Jordan)
PIKE FAMILY	**ESOCIDAE**
Grass pickerel	Esox vermiculatus Le Sueur
KILLIFISH FAMILY	**CYPRINODONTIDAE**
Starhead topminnow	Fundulus notatus (Rafinesque)
PERCH FAMILY	**PERCIDAE**
Blackside darter*	Hadropterus maculatus (Girard)
Logperch	Percina caprodes (Rafinesque)
Johnny darter	Boleosoma nigrum (Rafinesque)
Rainbow darter	Poecilichthys caeruleus (Storer)
Orangethroat darter*	Poecilichthys spectabilis Agassiz
Fantail*	Poecilichthys flabellaris (Rafinesque)
Greenside darter*	Etheostoma blennioides Rafinesque
SUNFISH FAMILY	**CENTRARCHIDAE**
Smallmouth black bass	Micropterus dolomieu Lacépède
Largemouth black bass	Micropterus salmoides (Lacépède)
Warmouth	Chaenobryttus coronarius (Bartram)
Green sunfish	Lepomis cyanellus Rafinesque
Bluegill	Lepomis macrochirus Rafinesque
Orangespotted sunfish	Lepomis humilis (Girard)
Longear sunfish	Lepomis megalotis (Rafinesque)
Rock bass	Ambloplites rupestris (Rafinesque)

*Not given in the American Fisheries Society list; from Hubbs & Lagler (1947).

Table 2.--Number and weight (in pounds) of each of the species of suckers collected, 1950, in each of the eight divisions of Jordan Creek, and the total number and total weight of each species collected in all divisions combined.

Division	Hog Sucker		White Sucker		Golden Redhorse		Quillback		Creek Chubsucker	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
1	106	8.25	40	1.83	16	1.43	---	---	---	---
2	211	18.56	12	2.15	17	2.62	1	0.12	1	0.05
3	223	16.92	50	4.28	14	1.06	---	---	1	0.01
4	249	15.08	136	13.59	18	1.51	---	---	6	0.55
5	523	17.53	29	1.04	184	1.80	4	0.07	2	0.14
6	444	9.47	97	12.52	395	4.10	32	0.53	---	---
7	343	7.74	42	3.29	210	4.20	26	0.59	2	0.17
8	259	2.65	7	0.09	170	1.23	104	2.77	10	0.36
All divisions	2,358	96.20	413	38.79	1,024	17.95	167	4.08	22	1.28

not abundant in the same pools, indicating a difference in habitat preferences. Like the white sucker, the hog sucker showed a tendency to move ahead of the shocker. Occasionally it was able to dash through the electrical field without becoming completely incapacitated. When stunned, it would sink to the bottom rapidly and for this reason was often difficult to collect.

Creek Chubsucker.--Fish of this species appeared in only 11 collections in the study area. Upstream above the study area, they were more abundant; 2.5 times as many specimens were taken in two short upstream sample stations (each 200 feet long) than were collected in the entire study area.

Spotted Sucker.--Only one specimen of this species was collected. It was taken in Division 3 after a heavy rain in October and presumably had moved up the stream from the Salt Fork River, where the species was rather abundant.

Golden Redhorse.--This species was represented in 79 per cent of the collections, but 95 per cent of the specimens were taken from the soft-bottomed, slow-flowing waters in the open area. They were usually in small schools of four to six individuals. All but 27 of the redhorse collected were of the 1950 brood (young-of-the-year) and only 4 of the 27 were unquestionably of adult size.

Minnow Family

The minnows were the dominant fish family in the Jordan Creek study area, comprising 75 per cent of the total number and 38 per cent of the total weight of all fish collected. There was a marked increase in their numbers from the wooded to the open area, table 8; the wooded area yielded 30 per cent, the open area 70 per cent, of the total number collected. The increase in weight was not so evident, indicating that the minnows from the wooded area were larger in average size than those from the upper, open area. In each division the minnows were more numerous than the fish of all other families combined, and only in Division 4 was their weight exceeded by the fish of any other one family--by the suckers and the sunfishes, table 9. In this division the stoneroller, which comprised 39 per cent of the weight of all minnows collected, was at its lowest level of abundance, table 3. Of the 13 species of minnows present in the study section, 3 species--the stoneroller, the hornyhead chub, and the bluntnose minnow--made up 73 per cent of the total weight of this family.

Carp.--One immature specimen taken in Division 4 was the only representative of this species in our collections.

Creek Chub.--Individuals of this species were taken in all but one collection. Their numbers increased progressively upstream, whereas their average size decreased.

Hornyhead Chub.--This species was the second most abundant minnow by weight and was represented in every collection. The larger individuals were found at the upper ends of fairly deep pools, usually in constricted riffles having currents of moderate velocity.

Rosyface Shiner.--Although this minnow was

Table 3.--Number and weight (in pounds) of each of the 10 most abundant species of minnows collected, 1950, in each of the eight divisions of Jordan Creek, and the total number and total weight of each species collected in all divisions combined.

Division	Stoneroller		Hornyhead Chub		Bluntnose Minnow		Creek Chub		Silverjaw Minnow	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
1	1,791	16.25	90	2.64	302	1.40	128	2.20	58	0.22
2	761	13.81	138	5.92	581	3.21	142	1.51	127	0.53
3	931	9.63	211	7.90	574	3.12	273	2.67	265	1.07
4	515	5.34	164	6.43	680	3.71	245	1.28	298	0.94
5	1,879	18.02	314	6.43	1,384	7.42	277	1.70	637	2.38
6	1,386	8.96	398	5.07	1,716	7.30	471	1.66	1,349	3.59
7	733	7.58	326	5.52	1,198	6.27	643	3.58	954	3.54
8	1,834	9.67	430	3.43	663	3.51	781	2.47	1,471	4.11
All divisions	9,830	89.26	2,071	43.34	7,098	35.94	2,960	17.07	5,159	16.38

Division	Common Shiner		Sand Shiner		Suckermouth Minnow		Spotfin Shiner		Redfin Shiner	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
1	174	4.05	3	0.01	75	0.73	5	0.04	15	0.04
2	154	3.53	4	0.02	74	0.77	7	0.03	2	+
3	139	3.11	2	0.01	90	1.12	4	0.02	4	0.01
4	142	3.34	16	0.08	10	0.09	18	0.13	33	0.09
5	88	0.45	288	1.13	30	0.25	9	0.05	10	0.03
6	97	1.05	784	2.64	30	0.21	22	0.13	10	0.02
7	22	0.52	616	2.20	17	0.09	128	0.68	35	0.15
8	10	0.08	631	2.06	9	0.10	80	0.59	27	0.12
All divisions	826	16.13	2,344	8.15	335	3.36	273	1.67	136	0.46

+ Less than 0.01 pound.

common in the Salt Fork River, only one specimen was collected in Jordan Creek. It was taken in Division 3 after heavy fall rains. Forbes & Richardson (1920) called this species Notropis rubrifrons and recorded it as being present in Illinois only in the Mississippi River drainage of the northern third of the state. Thompson & Hunt (1930) did not record it from Champaign County.

Redfin Shiner.-- This minnow was rather scarce in Jordan Creek collections, even though it is generally abundant in the smaller, slow-flowing streams of the Wabash River drainage in central Illinois.

Common Shiner.-- The weight and number of minnows of this species decreased progressively upstream. Eighty-seven per cent of the weight was taken in the wooded area. The greatest numerical abundance was in Division 1 and was associated with shade, rocky riffles, and short, shallow pools. The larger individuals were found in narrow but moderately deep riffles with swift currents.

Spotfin Shiner.-- This species, Notropis spilopterus, and a very similar species, N. whipplii, were both present in the Salt Fork River, but only the former was collected in Jordan Creek. It showed a

decided preference for the slow-flowing, soft-bottomed pools of Divisions 7 and 8.

Sand Shiner.--The sand shiner showed a sharp change in abundance between the wooded and open areas, with 99 per cent of the individuals coming from the upper, sunny area. Notropis volucellus, which closely resembles the sand shiner, was present in the Salt Fork River but was not collected in Jordan Creek.

Suckermouth Minnow.--Minnows of this species were most abundant in divisions of the wooded area and were associated with a steeper gradient and harder bottom than are found farther upstream. They were usually collected in riffles of moderate current and depth.

Silverjaw Minnow.--The weights and numbers of minnows of this species increased in an upstream direction. There was a distinct rise in abundance from the wooded area to the open area; 86 per cent of the specimens were collected in the open area. Moore, Pollock, & Lima (1950) pointed out that this minnow is morphologically adapted to tolerate intense light over a bright sandy bottom.

Fathead Minnow.--One specimen of the fathead was collected in Division 3 following high water stages during the fall. Forbes & Richardson (1920) reported that in Illinois this species is practically limited to the Mississippi River drainage, as they collected it from only four localities in the headwaters of the Embarrass River of the Ohio River drainage. Gerking (1945) had few records for it in western Indiana.

Bluntnose Minnow.--This, the second most numerous minnow in the study section, appeared in every collection. The greatest numbers were taken in quiet waters over soft bottoms in the open area. Its abundance was inversely proportional to the steepness of the stream gradient.

Stoneroller.--In number the stoneroller was the most abundant fish in the study section; in total weight it was exceeded by only the hog sucker. Minnows of this species, present in every collection, seemed to prefer narrow, shallow pools with gravel bottoms and rapid currents.

Catfish Family

The four species belonging to this family comprised a relatively small part of the total fish population of the Jordan Creek study section, table 9. These species, table 4, can be separated into two groups, based on habitat preferences: (1) the bullheads, which seek mud banks along larger pools, and (2) the stonecat and madtom, which inhabit rocky areas of moderate to swift currents. Because of differences in habitat preferences of the species represented and because of great differences in average size of individuals of these species, there was comparatively little correlation between the numbers and the weights of catfish taken in the eight divisions, table 8. The yellow bullhead made up 86 per cent of the total weight of representatives of the family.

Black Bullhead.--Four specimens of this species were collected. They were taken in three collections, each of which included yellow bullheads.

Table 4.--Number and weight (in pounds) of each of the species of catfishes collected, 1950, in each of the eight divisions of Jordan Creek, and the total number and total weight of each species collected in all divisions combined.

Division	Yellow Bullhead		Stonecat		Black Bullhead		Brindled Madtom	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight
1	5	1.11	21	0.89	--	----	15	0.16
2	3	0.65	17	0.60	--	----	3	0.04
3	8	1.74	6	0.25	--	----	--	----
4	20	3.94	1	0.07	1	0.25	--	----
5	23	2.69	--	----	--	----	--	----
6	9	0.39	--	----	--	----	--	----
7	33	1.35	--	----	1	0.16	--	----
8	54	3.66	--	----	2	0.17	--	----
All divisions	155	15.53	45	1.81	4	0.58	18	0.20

Yellow Bullhead.--This is the common bullhead of Jordan Creek, and specimens were taken in all eight divisions. Because of their dark color and preference for cover along the stream bank, yellow bullheads were difficult to collect with an electric shocker. Most of the young-of-the-year were found at the edges of shallow riffles. The largest individual collected was 9.7 inches in length and weighed 0.55 pound.

Stonecat.--Fish of this species were collected in only the four lower divisions of the study section, where generally they were found under stones in the larger riffles.

Brindled Madtom.--The madtom was taken in eight collections. Six of these collections also contained the stonecat. The madtom was restricted to rapids of the lower area, occurring in only Divisions 1 and 2.

Darter Family

The numerical abundance of darters in relation to the other families of fishes, table 9, was directly proportional to the steepness of the stream gradient. The actual numbers and weights of darters collected in each division, table 8, was influenced largely by the abundance of the four common species, table 5. For example, the greatest weight of darters was recorded for Division 1, where the large greenside darter was abundant.

Blackside Darter.--Only six specimens of this darter were taken. These were in separate collections and all were from the wooded area, in water of moderate depth and velocity.

Logperch.--One specimen was taken in a shallow, sandy pool in the upper area.

Johnny Darter.--This species was found in somewhat deeper waters than were the other darters and, because of this, it was more difficult to collect with the electric shocker. It was taken in greatest numbers in the upper three divisions, where it was associated with sandy bottoms.

Rainbow Darter.--The abundance of this darter decreased progressively upstream. It was most numerous in the larger, steeper riffles of the wooded area.

Orangethroat Darter.--This species closely resembles the rainbow darter in appearance, but its distribution in Jordan Creek was strikingly unlike that of the rainbow, fig. 24. Orangethroats increased in numbers upstream; 85 per cent of the specimens were taken in the upper, exposed area. Usually they were found either just above, below, or at the edges of the riffles and not so frequently in the most rapid currents.

Fantail.--This was the most numerous darter in Jordan Creek. It was commonly taken at the edge of, or just above, riffles and was more numerous in the upper half of the study area than in the lower.

Greenside Darter.--Rapid, rocky riffles were the characteristic habitat for this darter, which was more abundant in the wooded part of the study area than in the open part.

Sunfish Family

By weight, fish of the sunfish family appeared to be about equally distributed between the lower, wooded area and the upper, open area; by number, 71 per cent were taken in the open area, table 8. This lack of weight-number consistency was the

Table 5.--Number of each of the species of darters collected, 1950, in each of the eight divisions of Jordan Creek, and the total number of each species collected in all divisions combined.

Division	Fantail	Greenside	Orangethroat	Rainbow	Johnny	Blackside
1	56	135	96	173	2	3
2	27	129	7	121	1	1
3	56	138	7	78	1	--
4	86	63	- - -	78	4	2
5	157	91	128	31	4	--
6	173	91	139	51	13	--
7	186	66	144	27	8	--
8	210	35	219	15	7	--
All divisions	951	748	740	574	40	6

Table 6. -- Number and weight (in pounds) of each of the species of sunfishes collected, 1950, in each of the eight divisions of Jordan Creek, and the total number and total weight of each species collected in all divisions combined.

Division	Longear Sunfish		Smallmouth Black Bass		Rock Bass	
	Number	Weight	Number	Weight	Number	Weight
1	69	3.32	48	4.99	14	3.72
2	91	6.62	62	16.91	12	5.04
3	87	6.41	50	12.73	3	0.97
4	201	11.92	53	13.58	1	0.35
5	451	16.75	52	9.59	---	----
6	371	14.97	61	9.67	---	----
7	384	12.86	19	1.22	---	----
8	361	12.29	24	3.64	---	----
All divisions	2,015	85.14	369	72.33	30	10.08

Division	Green Sunfish		Bluegill		Largemouth Black Bass	
	Number	Weight	Number	Weight	Number	Weight
1	19	0.58	3	0.06	--	----
2	10	0.37	7	0.16	--	----
3	13	0.33	10	0.20	--	----
4	51	1.35	32	0.82	--	----
5	101	2.93	13	0.34	11	0.81
6	66	1.92	25	0.63	15	0.49
7	28	0.76	6	0.16	9	0.43
8	30	0.82	5	0.15	6	0.51
All divisions	318	9.06	101	2.52	41	2.24

result of great differences in size and abundance between the bass and the other sunfishes. The bass were relatively few in number and large. The other sunfishes were numerous and small. In Division 1, both the total number and the total weight percentages of the sunfish family were low, table 8, because of a scarcity of pools. In Divisions 2, 3, and 4 the percentages of total number were comparatively low while those of total weight were high. In these divisions were found most of the larger bass, table 6.

Smallmouth Black Bass. -- By weight, 67 per cent of the fish of this species were collected in the lower area, associated with more shade, deeper pools, steeper gradient, and more cover than were present in the upper area. The adults were taken usually in the deeper water of pools where there was such cover as boulders or root-masses. The young, however, were found most often in or near the riffle areas.

Largemouth Black Bass. -- The largemouth was taken only in the upper, open area, where the low stream gradient and absence of shade produced long warm pools with only moderate currents.

Warmouth. -- Two specimens were taken in Division 5 during fall recheck censuses. Since this species was not present in the earlier collections, it seems likely that these two specimens came from

a stone quarry that was connected with the headwaters of Jordan Creek during high-water periods.

Green Sunfish.--This fish, as collected in Jordan Creek, was too small to interest anglers. It was found in slow-flowing pools, especially along the shallow edges where grasses and roots provided cover. Its abundance was inversely related to the stream gradient.

Bluegill.--Although the bluegill was collected in all divisions of the study section, it was not abundant anywhere in Jordan Creek. Usually regarded as a pond fish, the bluegill showed a preference for long, shallow pools with reduced current velocity. Few specimens collected were of sizes desired by anglers. Only four were 5 inches or more in length.

Longear Sunfish.--This was the most abundant sunfish in Jordan Creek. In total weight collected, it was surpassed by only the hog sucker and the stoneroller. Its abundance increased sharply from the wooded area to the open area and seemed to be inversely related to the stream gradient. Sixty-seven per cent of the total weight of this fish was taken in the open area.

Orangespotted Sunfish.--Only one specimen (3.8 inches in total length) was collected. It was taken in Division 4.

Rock Bass.--The rock bass was collected in only the lower, wooded area. Although not abundant in Jordan Creek, it was reputed to be a favorite fish with local sportsmen. Only 2 of 30 rock bass collected were less than 6 inches long.

Miscellaneous Families

Two families were represented in Jordan Creek by single species: the pike family by the grass pickerel, the killifish family by the starhead topminnow. Neither species was abundant in the 1950 collections, table 7.

Grass Pickerel.--Only 16 specimens of this fish were collected, of which 14 were from the slow-flowing pools of the open area. Thompson & Hunt (1930) found fewer fishes in collections containing grass pickerel than in those which did not include this pickerel. No scarcity of minnows was observed in the Jordan Creek collections that contained grass pickerel.

Starhead Topminnow.--This topminnow showed a definite preference for the slow-flowing pools of the upper area; only three specimens were taken in the wooded area.

Association of Species

The association of fishes of Jordan Creek was studied in the relationship of families to each other and in the relationship of various species to ecological characteristics of the stream, as discussed in preceding paragraphs and summarized in tables 8, 9, and 10, It was further studied by comparing the distribution patterns of the most common species throughout the eight divisions of the study area, figs. 6-24. Species having similar patterns

Table 7.--Number and weight (in pounds) of grass pickerel and starhead topminnow collected, 1950, in each of the eight divisions of Jordan Creek, and the total number and total weight of each species collected in all divisions combined.

Division	Grass Pickerel		Starhead Topminnow	
	Number	Weight	Number	Weight
1	1	0.21	- -	- - -
2	1	0.20	- -	- - -
3	- -	- - -	1	+
4	- -	- - -	1	+
5	5	0.23	6	0.03
6	4	0.66	5	0.02
7	4	0.14	8	0.04
8	1	0.04	23	0.11
All divisions	16	1.48	44	0.20

+ Less than 0.01 pound.

Table 8.--Five most important fish families collected in Jordan Creek, 1950, and, for each family, the percentage of its total number and weight (in pounds) collected in each of the eight divisions; also, for each family, the total number and weight of fish collected.

Division	Suckers		Minnows		Catfishes		Darters		Sunfishes	
	Per Cent of Number	Per Cent of Weight	Per Cent of Number	Per Cent of Weight	Per Cent of Number	Per Cent of Weight	Per Cent of Number	Per Cent of Weight	Per Cent of Number	Per Cent of Weight
1	4.07	7.27	8.51	11.90	18.47	11.92	15.20	15.99	5.32	6.98
2	6.07	14.85	6.41	12.66	10.36	7.12	9.35	14.48	6.33	16.04
3	7.23	14.07	8.03	12.37	6.31	10.98	9.15	14.30	5.67	11.38
4	10.27	19.41	6.83	9.25	9.91	23.51	7.61	9.18	11.79	15.46
5	18.62	13.00	15.84	16.34	10.36	14.85	13.43	14.56	21.84	16.77
6	24.30	16.82	20.18	13.22	4.05	2.15	15.26	10.19	18.71	15.26
7	15.64	10.10	15.06	13.00	15.32	8.33	14.12	10.94	15.51	8.51
8	13.81	4.49	19.13	11.28	25.23	21.14	15.88	10.35	14.82	9.60
Total number	3,984		31,032		222		3,060		2,875	
Total weight in pounds		158.30		231.76		18.12		11.88		181.41

Table 9.--Five most important fish families collected in Jordan Creek, 1950, and the percentage each represented of the total number and weight (in pounds) of all fishes in each of the eight divisions and in all divisions combined.

Division	Suckers		Minnows		Catfishes		Darters		Sunfishes	
	Per Cent of Number	Per Cent of Weight	Per Cent of Number	Per Cent of Weight	Per Cent of Number	Per Cent of Weight	Per Cent of Number	Per Cent of Weight	Per Cent of Number	Per Cent of Weight
1	4.68	20.54	76.26	49.22	1.18	3.86	13.43	3.40	4.42	22.61
2	8.88	27.60	73.05	34.45	0.84	1.52	10.50	2.02	6.68	34.18
3	8.88	29.59	76.99	38.08	0.43	2.64	8.64	2.26	5.03	27.42
4	13.09	35.91	67.87	25.04	0.74	4.98	7.46	1.27	10.81	32.79
5	11.02	22.00	73.06	40.47	0.34	2.88	6.11	1.85	9.33	32.52
6	11.73	30.52	75.88	35.12	0.11	0.45	5.66	1.39	6.52	31.74
7	10.01	24.78	75.12	46.68	0.55	2.34	6.95	2.01	7.17	23.91
8	7.35	12.71	79.38	46.80	0.75	6.84	6.50	2.20	5.70	31.17
All divisions	9.66	26.24	75.26	38.42	0.54	3.00	7.42	1.96	6.97	30.07

Table 10. -- General ecological characteristics of the eight divisions of Jordan Creek; indicated for each division are the species of fishes characteristic for the division, those that were dominant, and those that were scarce at the time of the 1950 census.

Ecological Characteristic	Division 1	Division 2	Division 3	Division 4	Division 5	Division 6	Division 7	Division 8
Gradient (feet per mile)	34.0	24.5	20.8	17.0	8.5	7.6	9.4	13.3
Per cent of water shaded	75	85	80	80	15	5	10	0
Dominant bottom materials	Bedrock Gravel	Bedrock Gravel	Bedrock Gravel	Sand Bedrock Gravel	Sand Gravel	Sand Gravel	Silt Sand Gravel	Silt Sand Gravel
Use of surrounding land	Permanent pasture Timber	Permanent pasture Timber	Permanent pasture Timber	Permanent pasture Timber	Permanent pasture	Permanent pasture Soybeans	Temporary pasture Soybeans	Permanent pasture Soybeans
Characteristic species	Stoneroller Common shiner Rainbow darter	Hog sucker Common shiner Rock bass Smallmouth black bass	Hog sucker Hornyhead chub Creek chub Greenside darter	Hog sucker White sucker	Stoneroller Bluntnose minnow Longear sunfish	Bluntnose minnow Silverjaw minnow Sand shiner Longear sunfish	Bluntnose minnow Silverjaw minnow	Silverjaw minnow Fantail Orangethroat darter
Species at their peaks of abundance	Common shiner Stonecat Brindled madtom Rainbow darter Blackside darter	Hog sucker Rock bass Smallmouth black bass	Hornyhead chub Suckermouth minnow Creek chub Greenside darter	White sucker Creek chubsucker Yellow bullhead Black bullhead Bluegill	Stoneroller Bluntnose minnow Longear sunfish Green sunfish Largemouth black bass	Sand shiner Golden redhorse Johnny darter Grass pickerel	Spotfin shiner Redfin shiner	Silverjaw minnow Quillback Orangethroat darter Fantail Starhead topminnow
Species at their lowest abundance (but not absent from any section)	Bluntnose minnow Silverjaw minnow Hornyhead chub Longear sunfish Bluegill	Fantail Johnny darter	Spotfin shiner Sand shiner Golden redhorse	Stoneroller Suckermouth minnow Creek chub Orangethroat darter		Yellow bullhead	Suckermouth minnow	Smallmouth black bass Rainbow darter Greenside darter Common shiner White sucker Hog sucker

of distribution--that is, those increasing or decreasing in abundance in the same divisions of the stream--were considered associated, either with each other or with similar or related ecological factors. The association of several species was measured statistically.

The fish collections included a large proportion of the fish population present in each part of the stream censused, and so data on the individual species lend themselves to statistical treatment. The usual statistical measures of association based on the presence or absence of a species were of no significance in the treatment of these data, because most of the abundant fishes were taken in all 52 collections. Coefficients of correlation (r) between figures involving distribution of the various species were calculated to give indices of association. In species of the darter family and in three species of minnows, the indices were based on numbers of individuals, in all other species on total weights. In order to reduce the number of mathematical calculations and make the size of the samples as nearly uniform as possible, the analyses were based on the total collections from each of the eight divisions rather than on separate collections. Each of the correlation coefficients is simply a mathematical expression of the degree of similarity between the distribution patterns of the species being compared; the figures do not explain or measure any other relationship between the species.

Because the smallmouth black bass was the fish most sought after by Jordan Creek anglers, particular attention was given the fish communities with which it was associated. Its distribution was compared with that of each of several other abundant species, table 11.

Table 11.--Coefficient of correlation (r) for the weight distribution of the smallmouth black bass and that of nine other species of fishes in the eight divisions of Jordan Creek, 1950.

Species	r
Hog sucker	0.85
Hornyhead chub	0.62
Common shiner	0.56
White sucker	0.35
Stoneroller	0.04
Green sunfish	0.01
Longear sunfish	-0.18
Golden redhorse	-0.22
Creek chub	-0.73

A graph, fig. 5, was prepared to show the relative abundance of the smallmouth and the other main groups of fishes in a series of 24 pools ranked as good, mediocre, or poor on the basis of the weight of bass they contained. A high bass population seemed to be associated with a high percentage of suckers and a low percentage of minnows. The percentages of sunfishes (exclusive of smallmouth bass) and miscellaneous species were fairly constant in this series of pools, dropping off only slightly where the minnows were dominant. A direct relationship between bass and suckers and an inverse relationship between bass and minnows probably reflected the habitat preferences of these fishes.

The smallmouth, fig. 6, and the hog sucker, fig. 7, had a similar weight distribution, being most abundant in Division 2 and generally decreasing in their abundance upstream. The highest correlation of the smallmouth ($r = 0.85$) was with the hog sucker and is significant at the 1 per cent level. These species have similar distributions in Illinois. The high degree of association in Jordan Creek probably is best explained by the preference of both for hard-bottomed pools.

The hornyhead chub, fig. 8, had a weight distribution pattern in the study section somewhat similar to that of the smallmouth black bass, although the weight of the chub was greatest in Division 3 and the weight of the smallmouth was greatest in Division 2. The correlation coefficient of 0.62 between the weights of these species is somewhat high but not significant.

The abundance of the longear sunfish, fig. 9, reached a peak in Division 5 and decreased at stations upstream and downstream from Division 5. Gerking (1949) suggested that the presence of the longear sunfish was antagonistic to the smallmouth black bass in three streams that he surveyed. Antagonism between these species did not seem to prevail in Jordan Creek. There was a negative correlation ($r = -0.18$) between the weight of the smallmouth and that of the longear sunfish, but it is not significant. However, the negative correlation ($r = -0.73$) between the weight of the smallmouth black bass and the weight of the creek chub is significant. This strong negative correlation reflects the upstream increase of the chub and the difference in habitat preference between the two species. The creek chub, which is a headwater form, showed a gradual increase in numbers in the upstream stations, but in weight it had an irregular distribution pattern, fig. 11. The graph for this chub and that for the hornyhead chub indicate these fish are of smaller average sizes progressively up-

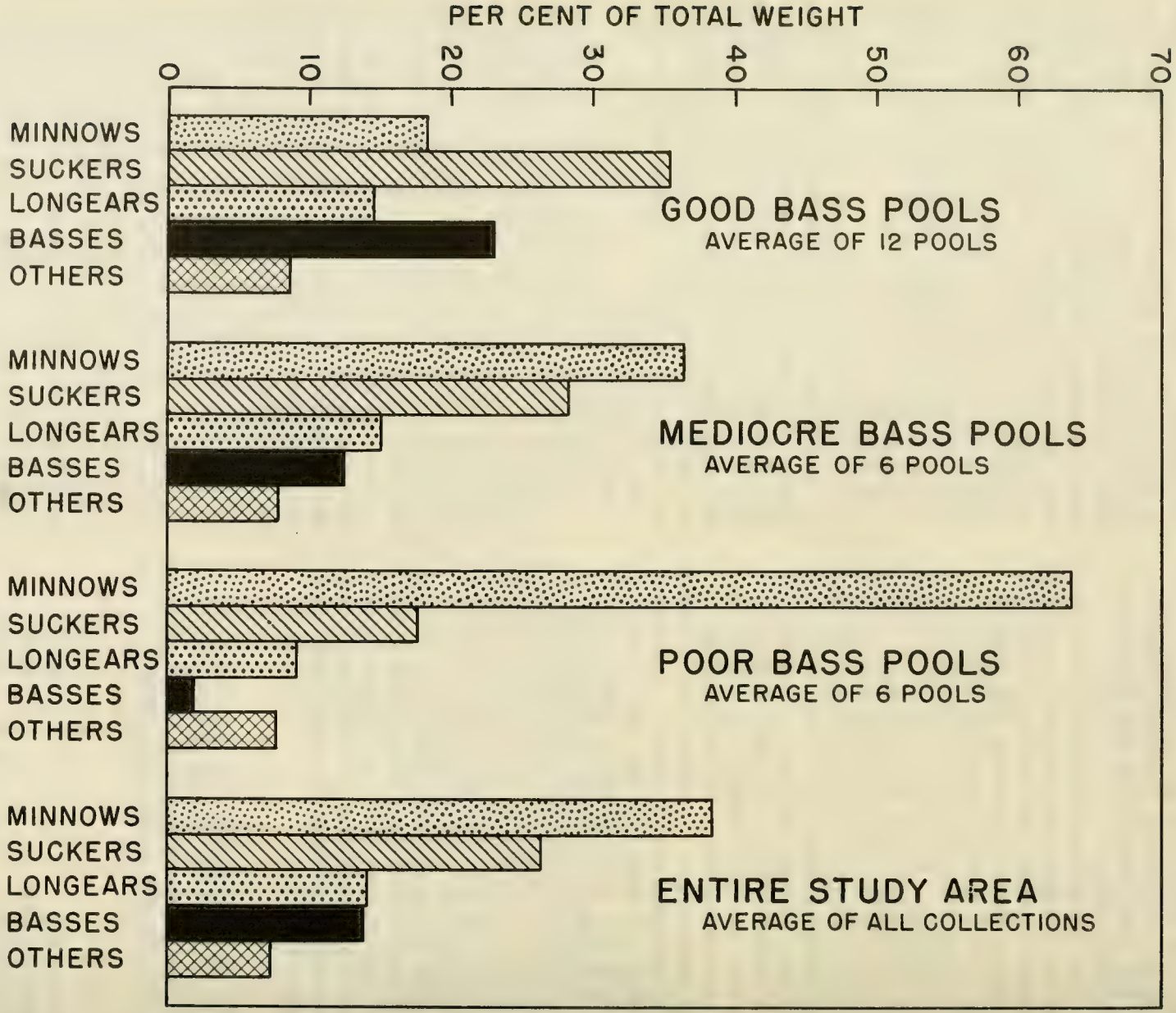
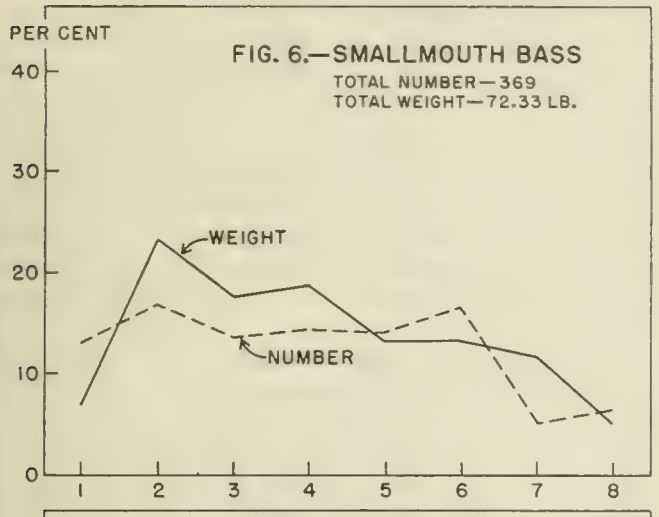
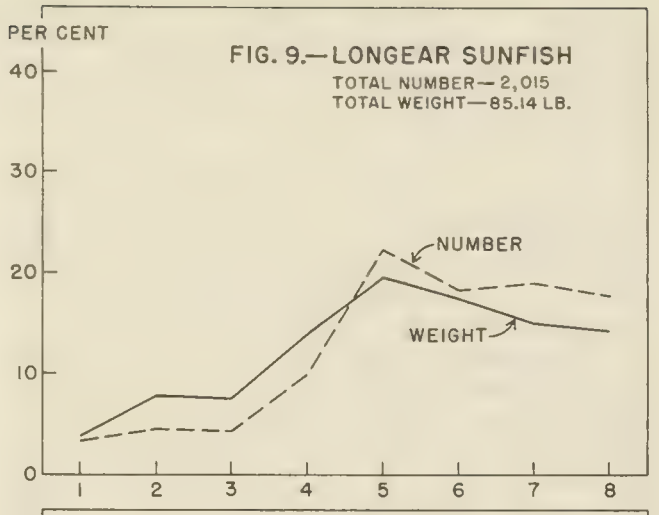
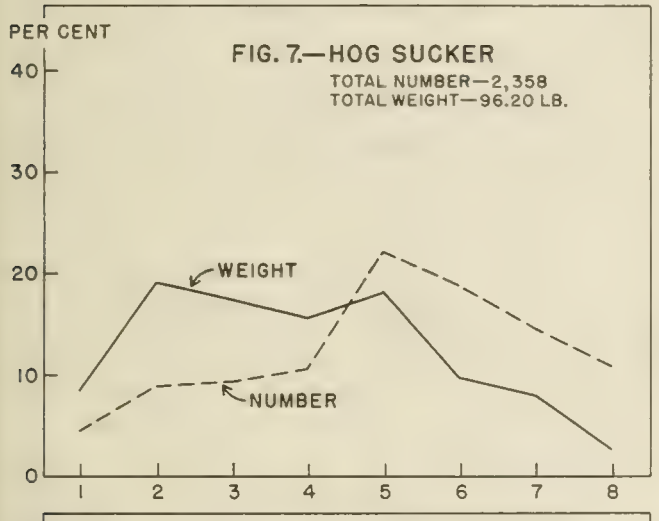
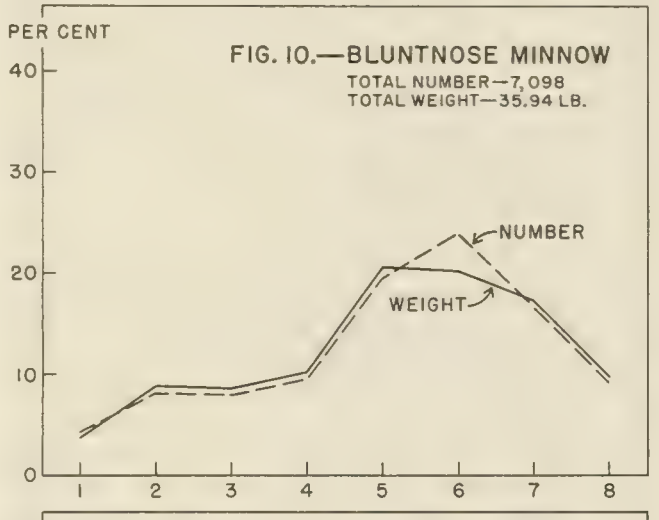


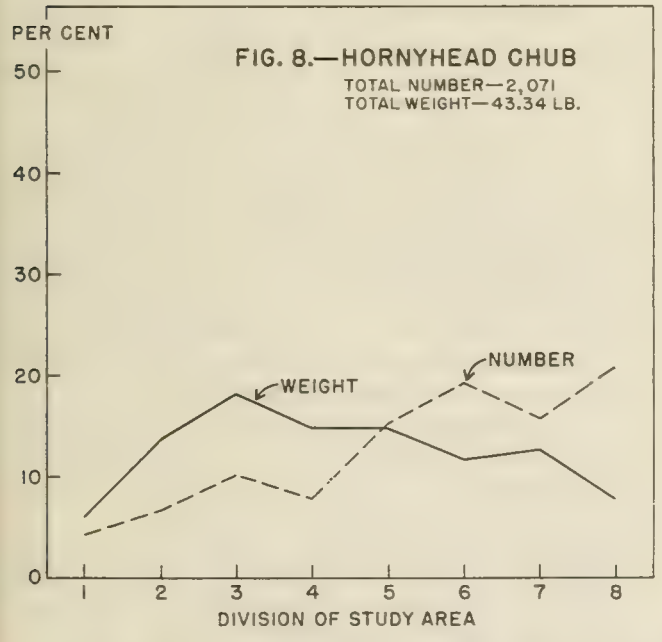
Fig. 5. -- Per cent of the total weight represented by five groups of fishes in each of three groups of Jordan Creek pools classified according to whether these pools contained good, mediocre, or poor bass populations, 1950. The data for the entire study area are also given.

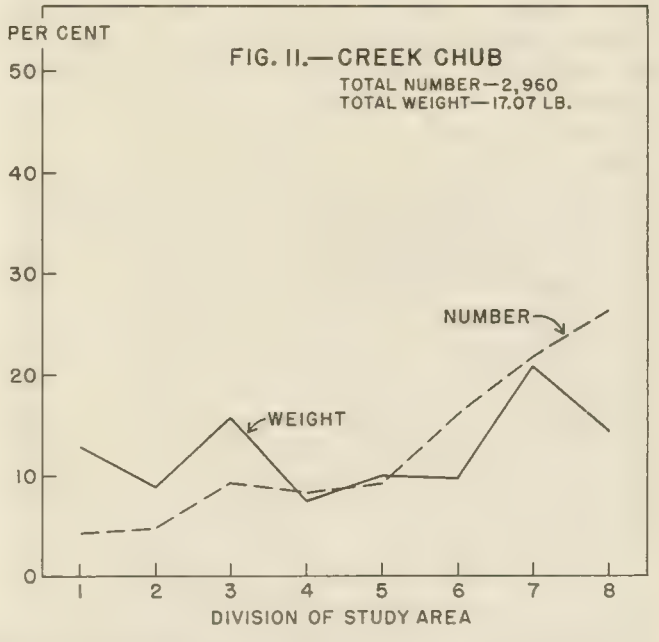












Figs. 6-11. -- Distribution (in per cent) of the number and weight of each of six species of fish collected in the eight divisions of the Jordan Creek study area, 1950.

stream. The bluntnose minnow, fig. 10, which showed a general increase in numbers up to Division 6, dropped off in the last two divisions; it had a distribution very similar to that of the longear sunfish.

Figs. 12-17 present an interesting picture of the succession of fishes in Jordan Creek. The rock bass, fig. 12, the stonecat, fig. 13, and the brindled madtom were present in only the fast, rock-bottomed pools of the lower area and showed a general decrease in the upstream stations of this area.

The common shiner, fig. 14, was present in all eight divisions but showed a general decrease of weight and number in the upstream divisions. Although we are more interested in the weight than in the number of a species, an interesting correlation ($r = 0.78$) was found between the number of smallmouth black bass and the number of common shiners. In Illinois the common shiner has a pattern of distribution similar to the patterns of the smallmouth and the hog sucker; all are scarce in the southern part of the state and increase in abundance northward.

The smallmouth black bass generally is found in smaller streams than the largemouth, and when these species occur together the smallmouth is usually more abundant upstream than the largemouth. In Jordan Creek this situation was reversed; the largemouth was taken in only the upper area, fig. 15, and the smallmouth more abundantly in the lower, fig. 6. As was mentioned previously, Jordan Creek is unusual in that the upper area has more characteristics typical of larger streams--slower currents, larger pools, and softer bottoms--than has the lower area. To some extent this situation has caused for some of the fish a reversal of the distribution typical for a stream of the size of Jordan Creek.

The sand shiner, fig. 16, silverjaw minnow, fig. 17, and spotfin shiner were much more abundant in the upper area than in the lower. The distributions of the numbers of these three species were correlated. The silverjaw minnow and the sand shiner had a correlation coefficient of 0.96, which was the highest correlation calculated. The spotfin had a correlation coefficient of 0.75 with the silverjaw, 0.67 with the sand shiner. These associations probably are explained by the fact that these three species have a preference for the soft bottoms of sand and silt in the upper area.

The general pattern of distribution of the white sucker, fig. 18, was bimodal, with a low in Division 5 and peaks in Division 4 and Division 6. The general distribution of the bluegill, fig. 19, was somewhat similar to that of the white sucker. However, bluegills usually were collected near the banks with cover, whereas white suckers were collected in the open water of the pools. The green sunfish, fig. 20, reached its peak of abundance in Division 5, in which the bluegill and the white sucker were low in abundance. The white sucker had a higher correlation coefficient with the smallmouth black bass than did the green sunfish.

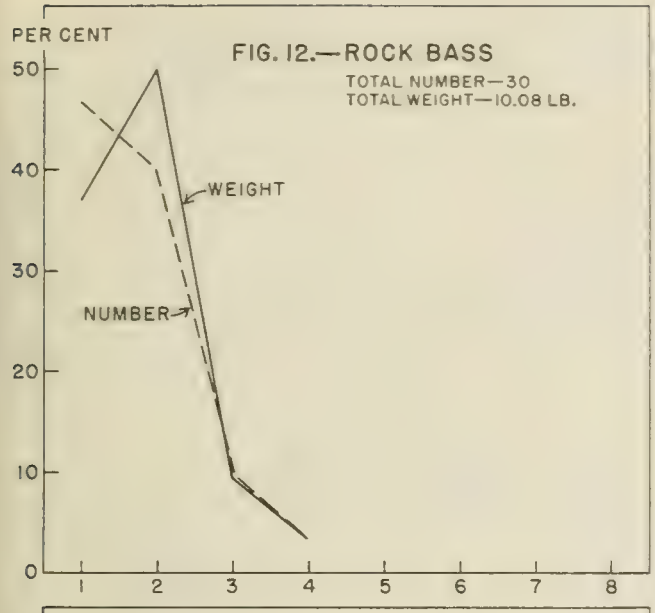
In comparing the distribution of the stoneroller with that of the white sucker, figs. 21 and 18, it was discovered that in the divisions of the stream where the number and weight of the stoneroller were high those of the white sucker were low, and vice versa. However, these two bottom feeders probably do not compete in their habitats, since the stoneroller was found in faster and more shallow water than the sucker. The yellow bullhead, fig. 22, had an irregular distribution in Jordan Creek, with only a general increase in abundance in the upstream stations. The large adults of this species were found at the edges of pools where the water was deep and where the banks were covered with grass or roots. The young of the golden redhorse, fig. 23, showed a definite preference for the softer bottoms of the upper area. The correlation coefficient for the weights of the golden redhorse and the smallmouth black bass was not significant.

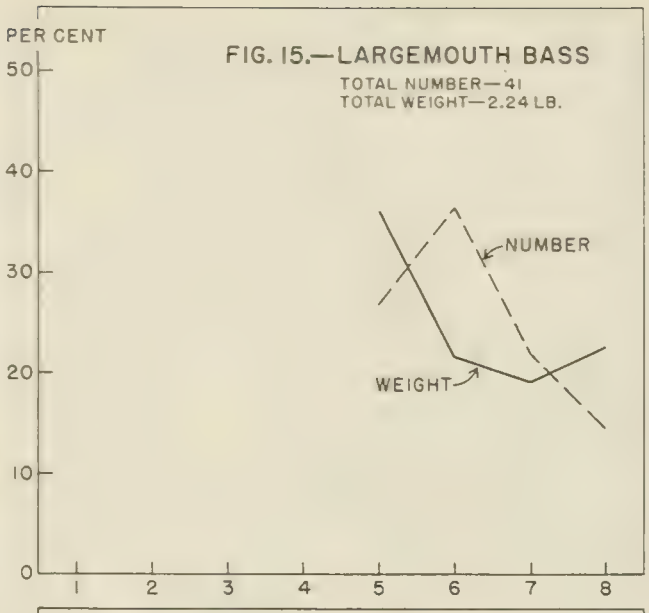
In relative abundance, the greenside and rainbow darters were replaced upstream by the fantail and the orangethroat darter, fig. 24. Trautman (1930) noted differences in habitat preferences of the rainbow darter and the orangethroat darter.

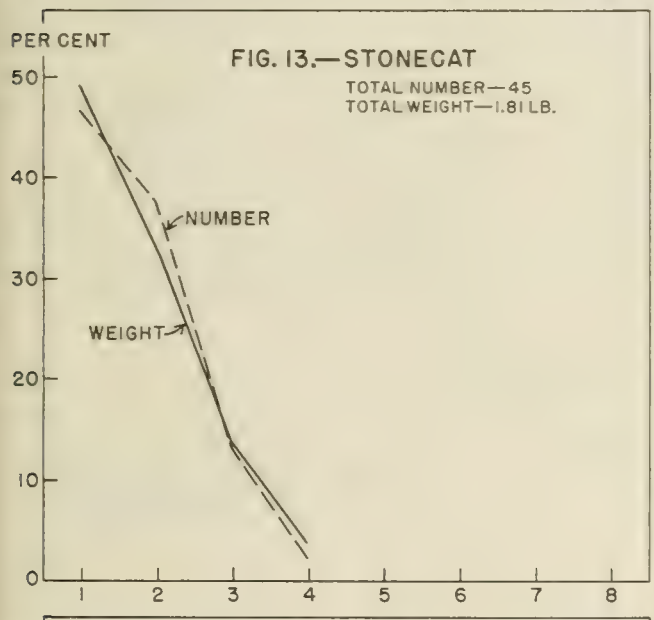
In the Jordan Creek study section, the rainbow had a correlation coefficient of 0.76 (significant at the 5 per cent level) with the greenside, of -0.85 with the fantail, of -0.55 with the orangethroat, a species very similar in appearance to the rainbow and often confused with it. The greenside had a correlation coefficient of -0.81 with the fantail, of -0.60 with the orangethroat. The orangethroat had a correlation coefficient of 0.88 with the fantail.

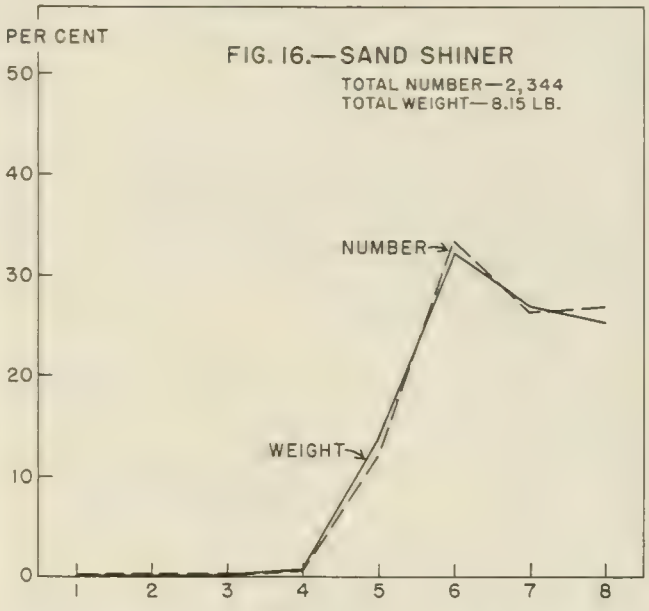
The rainbow and the greenside showed a preference for the larger and faster rapids, whereas the orangethroat and the fantail showed a preference for the smaller and slower rapids.

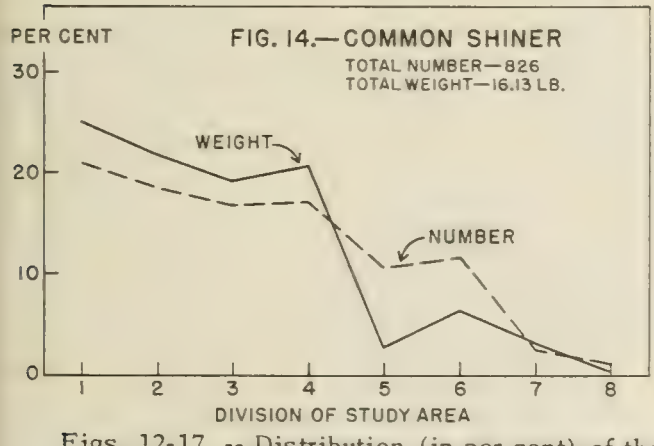
The associations and succession of darters are due to steep, swift rapids with large boulders in the lower area and less turbulent, gravel riffles in the upper area.

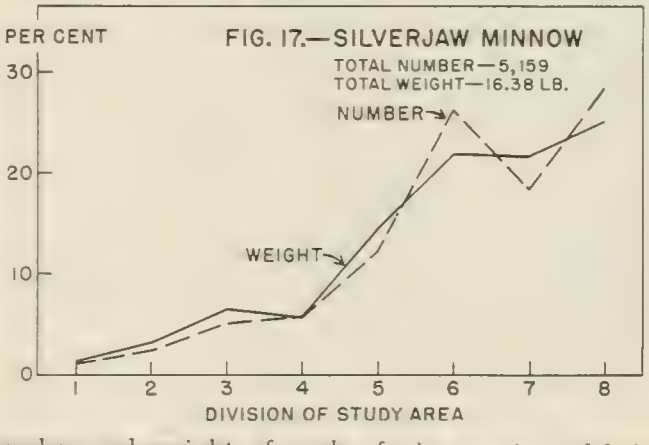




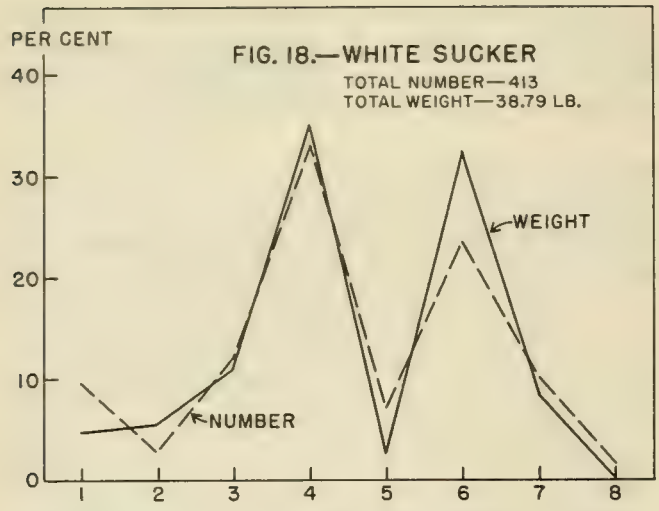


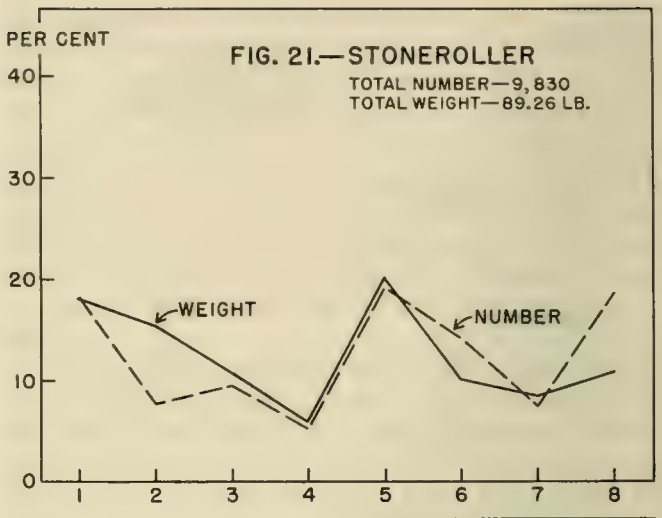


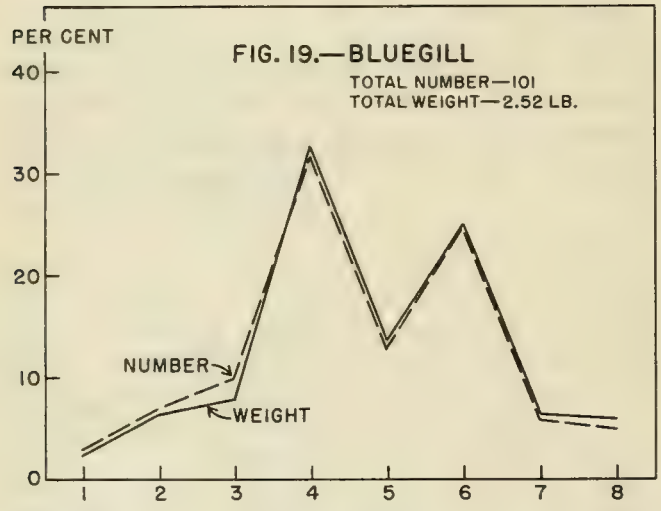


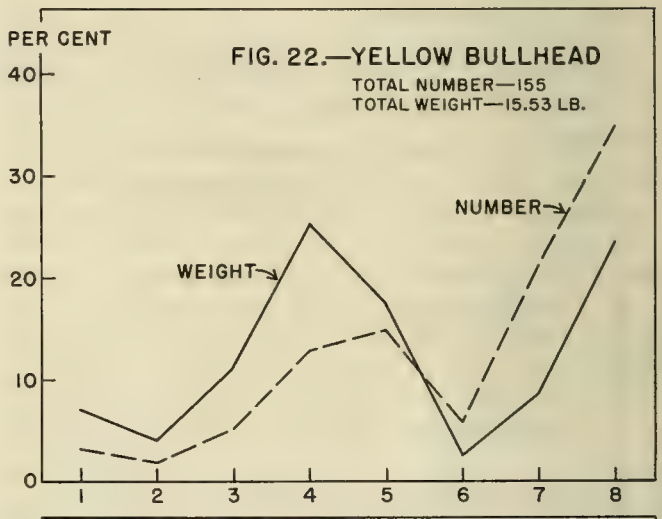


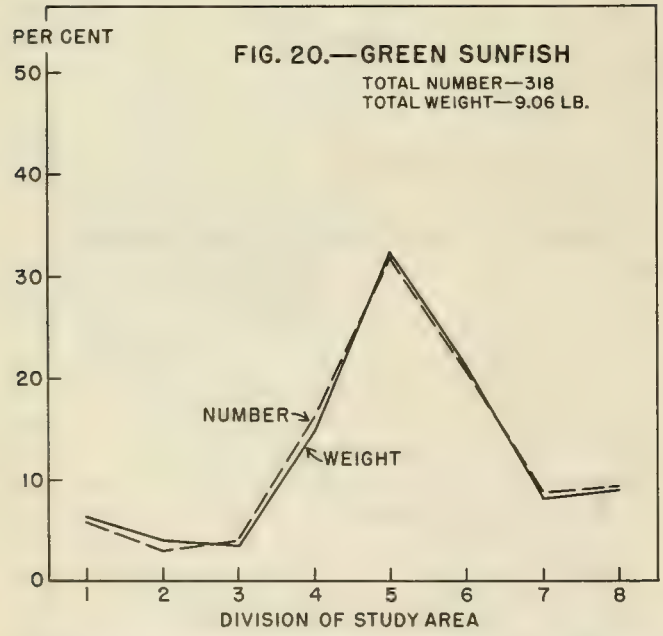
Figs. 12-17. -- Distribution (in per cent) of the number and weight of each of six species of fish collected in the eight divisions of the Jordan Creek study area, 1950.

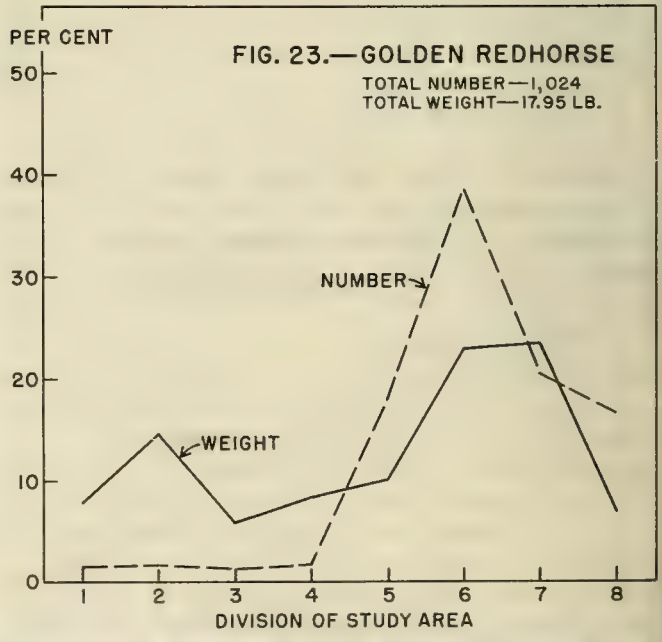












Figs. 18-23. -- Distribution (in per cent) of the number and weight of each of six species of fish collected in the eight divisions of the Jordan Creek study area, 1950.

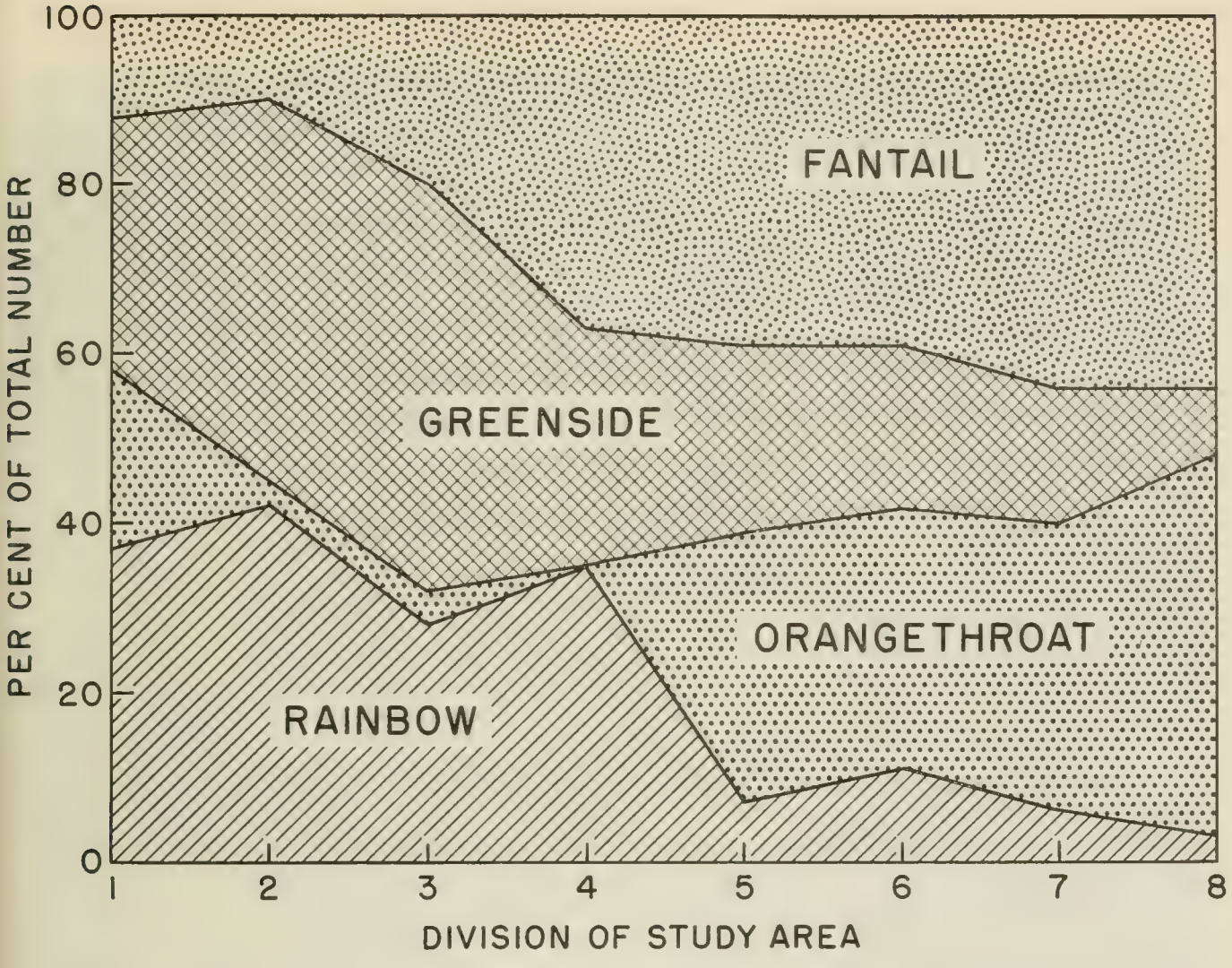


Fig. 24. -- Distribution (in per cent) of the four most numerous darters in the eight divisions of the Jordan Creek study area, 1950.

Discussion

Jordan Creek was found to have an abundant fish population, not only from the standpoint of total number and weight but also from that of variety of species. The abundance of fish was probably related to the fertility of the lands drained by this creek, whereas the number of species reflected the variation in the stream habitat.

A natural division of the study area into a rough, wooded area downstream and a flat to rolling, open area upstream facilitated the relating of fish distribution to ecological conditions. The lower area showed more typical upstream characteristics than did the upper area with its long, slow-flowing pools. This reversal of upstream-downstream conditions tended to emphasize the specific factors influencing fish distribution.

Several species (rock bass, stonecat, brindled madtom, and blackside darter) were restricted to the lower area, whereas other species (largemouth black bass, sand shiner, spotfin shiner, and starhead topminnow) occurred abundantly only in the upper area. The number and weight of the common shiner decreased progressively upstream; the number and weight of the silverjaw minnow decreased progressively downstream. The distribution of several species (white sucker, stoneroller, bluegill, green sunfish, and yellow bullhead) seemed to be influenced by specific habitats not restricted to either the upper or lower areas. A few species were represented by only one or two specimens and were considered only temporary residents of Jordan Creek.

Species with similar general distribution patterns in the study section may have different

habitat preferences and be influenced by different specific environmental factors. For example, the rock bass and the stonecat had very similar general patterns of distribution, figs. 12 and 13; but the rock bass inhabited deep, shaded pools and the stonecat swift, rocky areas, fig. 25.

It was usually difficult to distinguish the factors that actually defined the habitat for each species. Stream gradient, amount of shaded water surface, dominant bottom materials, and the use of surrounding lands appeared to influence the distribution of Jordan Creek fishes. But it should be kept in mind that the fishes were actually influenced by more specific environmental factors. The abundance of the bluntnose minnow, for example, varied inversely with the stream gradient but its distribution may actually have been governed by some more definite factor determined by stream gradient, such as velocity of flow, size of pools, steepness of riffles, kinds of bottom materials, or the associated food organisms.

Summary

1. The fish population in a continuous section of Jordan Creek was censused with an electric shocker to form a basis for further investigation of the fishes of this small, warm-water stream.

2. The 4-mile study section was separated into eight divisions, each approximately one-half mile in length. The lower four divisions were in a rough, wooded area. Here the stream was composed of short, hard-bottomed pools and steep riffles. The four divisions above this wooded area were in open, sunny, farm and pasture land. Here the stream gradient was low, resulting in long, slow-flowing pools.

3. In the eight divisions of the study area, the numbers and weights of fish taken were tabulated for each species and for each family of fishes. Particular attention was given the relationship between the distribution of the fishes and the characteristics of the habitat.

4. Forty species of fishes comprised the population. The minnows made up 75 per cent of the total number and 38 per cent of the total weight of all fishes. Sunfishes were second and suckers were third in total weight. By number the stoneroller was the most abundant species and by weight it was second to the hog sucker.

5. The distribution of species appeared to be strongly influenced by four primary factors of the habitat: stream gradient, shading of water surface, dominant bottom materials, and use of surrounding land.

6. The smallmouth black bass, the favorite fish with Jordan Creek anglers, had a distribution by weight similar to that of the hog sucker. There was a direct correlation in weight between bass and suckers in individual pools and an inverse relationship in weight between bass and minnows.

7. Certain species (rock bass, stonecat) were found only in the wooded area, with a high gradient, whereas others (largemouth black bass, sand shiner) were abundant only in the slow-flowing pools of the upper, open area.

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Fig. 25. -- Quiet pool, in foreground, typical of the Jordan Creek pools in which rock bass and smallmouths were found in 1950. In swift, rocky areas, like the riffle in the background, stonecats, madtoms, and rainbow darters were taken.

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